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(54) IMPROVEMENTS IN OR RELATING TO INSULATED CABLES PROVIDED WITH TERMINAL SEALS

(71) We, SIEMENS AKTIENGESellschaft, a German company, of Berlin and Munich, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an insulated cable provided with a terminal seal.

In the manufacture of terminal seals for plastics-insulated heavy-current cables, it is known to surround the cable end by a body consisting of casting resin. In order to achieve this, a casting resin in the liquid state can be poured into a plastics mould which surrounds the cable end and which consists of a lower part and an upper part, when vertically disposed with the cable end uppermost, and the casting resin hardens in this plastics mould.

However, the use of such terminal seals comprising a casting resin for heavy-current cables having a polyolefinic, especially a polyethylenic, insulation around a conductor involves difficulties owing to the different thermal expansion coefficients of the hardened casting resin and of the polyolefin. Gaps between the cable insulation and the body of casting resin, can be produced during the operation of the cable, whereby partial discharges are produced, which may result in a destruction of the insulation.

According to the present invention, there is provided a cable comprising a conductor surrounded by a layer of insulation and by a coaxial screen disposed about the insulation, the cable being provided with a terminal seal comprising (a) a multi-part mould member having a tapering metallic inner portion, a central portion formed of an elastomeric insulating material, and a cap-form outer portion, the terms inner, central and outer being as hereinafter defined, and (b), as an insulating composition, an elastomeric filling compound and an adhesive, the insulating composition being cast within the multi-part mould member and around the cable insulation, and the adhesive ensuring good adhesion between the insulating composition and the cable insulation.

The term "outer" is used herein to imply nearer to the end of the cable than "central", and the term "central" is used herein to imply nearer to the end of the cable than "inner".

The terminal seal can be readily fitted to, for example, heavy-current cables insulated with a thermoplastic plastics. The insulating composition remains united with the cable insulation without the formation of a gap, even during the operation of the heavy-current cable, despite the fact that its thermal expansion coefficient differs from that of the cable insulation.

Preferably, the central portion of the mould body is a cylindrical or outwardly frusto-conical tapering portion.

The present invention provides a terminal seal on a cable which, owing to the use of an elastomeric insulating composition and preferably of an elastomeric cable insulation, directly follows the thermal movements of the cable insulation, so that no gaps are set up between the cable insulation and the insulating composition. In addition, the formation of a gap is prevented by virtue of the fact that the insulating composition includes, in addition to the elastomeric insulating and filling compound, an adhesive which imparts to the insulating and filling compound a high degree of adhesion to the cable insulation.

The terminal seal is suitable both for heavy-current cables having an insulation consisting of polyvinyl chloride and for heavy-current cables having an insulation consisting of polyethylene. In the case of polyethylene insulation, there may be employed either a high-pressure or low-pressure polyethylene or a cross-linked polyethylene. The terminal seal may also be employed with advantage for cables having an insulation consisting of an elastomeric material such as, for example, a terpolymeric rubber formed by terpolymerizing ethylene, propylene and a diene monomer.

For the elastomeric filling compound of the insulating composition also containing the adhesive, a filling compound which has proved particularly suitable consists of a mixture based upon castor oil and polyisocyanic acid esters. Such an insulating com-

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pound, which is cold-cast and which is cross-linked in the cold state, is sold, for example, under the trade name "Sibit" by Siemens AG. An essential feature of this insulating compound is that it changes into an elastomeric condition due to a cross-linking reaction after having been cast.

The terminal seal of the cable of the present invention may be employed both indoors and outdoors. For outdoor use, it is desirable in accordance with a preferred embodiment of the present invention to provide the insulating central mould portion with drip shields which form an integral unit with the central mould portion. These drip shields may alternatively be mounted on the insulating central mould portion so that a terminal seal which was initially suitable for indoor use may subsequently be converted for outdoor use.

For a better understanding of the present invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawing in which:

Figure 1 is an axial cross-section through a cable according to one embodiment of the present invention; and

Figure 2 is an enlarged view of a joint of the cable of Figure 1.

Figure 1 shows a terminal seal 1, which is shown as a seal intended for indoor use in the left-hand part of the drawing, and as a seal intended for outdoor use in the right-hand part of the drawing. The seal 1 is mounted on the end of a 20-kV heavy-current cable 2 which comprises a conductor 3 which is surrounded by a layer of insulation 4 consisting of high-pressure polyethylene. This insulation 4 is provided with a weakly conductive layer (not shown), to which there is applied a coaxial copper screen 5 built up of individual wires, over which is a cable sheathing 6 consisting of polyvinyl chloride.

The terminal seal 1 comprises a mould member 10, which consists of an inwardly tapering metallic inner portion 11, an outwardly tapering elastomeric insulating central mould portion 12 and a cap-form outer portion 13, and an elastomeric insulating composition 17 introduced into the mould member 10. The inner portion 11 serves as a support for the elastomeric insulating central mould portion 12 and is therefore formed of a metallic material. The inner portion 11 is furthermore preferably longitudinally divided, so that an earthing connection 19 connected to the coaxial copper screen 5 may be more readily removed from within the inner portion 11. The two halves of the inner portion may be connected together by a tongue and groove arrangement, with or without simultaneous adhesive bonding, or by means of hose clips or screws.

The rigid metallic inner portion 11 en-

sures stability of the external form of the terminal seal and thus the central seating of the central insulating portion 12 in the region of a deflector 18 which is mounted in a manner known *per se* on the terminal end region of the screen 5 of the heavy-current cable 2. The deflector 18 employed for the field control may be formed of a conductive rubber, of a metal, of a metal-coated or carbon-coated plastics material or of wound-on conductive tapes. The deflector may also be produced by winding conductive tapes around a correspondingly shaped insulating wrapping.

As already mentioned, the central insulating portion 12 consists of an elastomeric material. Synthetic rubbers, for example a terpolymer formed by terpolymerizing ethylene, propylene and a diene monomer are particularly suitable for this purpose. The elastomeric insulating portion 12 and the insulating composition 17 are compatible with one another so that, in the event of a thermally induced increase in the volume of the cable insulation 4 and of the insulating composition 17, the expansion takes place radially. On subsequent cooling and decrease of the volume, the elastomeric insulating central portion 12 can follow the insulating composition 17 in a contraction without becoming detached therefrom.

The cap-form outer portion 13 of the mould member 10 is preferably formed of the same elastomeric material as the central insulating portion 12; the portion 13 may contain a weakly conductive material. This outer portion 13 is preferably so shaped that, while being fixedly seated on the insulating central portion 12 and on a cable connector 20, or on a corresponding connecting pin, it also permits thermally induced longitudinal movements of the cable insulation 4, including the conductor covering layer (not shown) on the conductor 3. For this purpose, the cap-form outer portion 13 may be constructed with expansion bellows.

The three parts of the mould member 10, i.e. the inner portion 11, the central insulating portion 12 and the cap-form outer portion 13, are readily connected together by virtue of the fact that they comprise annular beadings 15 and grooves 16 respectively at the points of connection. For a better understanding, this connection is shown on an enlarged scale in Figure 2 in the case of the joint between the inner portion 11 and the central insulating portion 12. The interengaging regions of the individual parts of the mould member 10 may additionally be adhesively bonded together; the sealing, which is necessary on the introduction of the insulating composition 17 into the mould member 10, is thereby improved. As a bonding agent, there may be employed, for ex-

ample, the same composition as composition 17, which contains an adhesive.

Another possible method of connecting the inner portion 11 to the central insulating portion 12 is to press the central portion on to the inner portion and to secure it by means of a hose clip, or to employ an intermediate ring which is fixedly connected to the inner end of the central portion 12 and is connected in fluid-tight manner to the inner portion 11, for example by means of a bayonet joint.

The sealing of the inner portion 11 to the cable sheathing 6 is effected with the aid of an adhesive tape which is wound onto the cable sheathing. The metallic inner portion 11 may be provided with an earthing connection and may be directly clamped, as a conductive connection, to the copper screen 5 of the heavy-current cable 2. If the cable insulation 4 is sufficiently insensitive to soldering heat, the inner portion 11 may also be soldered to the copper screen 5. In this construction, no separate earthing connection would have to be provided.

The filling of the terminal seal 1 with composition 17 may be effected from the outermost end without technical aids such as, for example, valves or presses. Once the portions 11 and 12 are full, the cap-form outer portion 13 is fixed in position and serves as a cover for the top surface of the insulating composition and for centring the heavy-current cable until the latter has been fixedly located by the cross-linking insulating composition itself. The cap-form head portion may be pulled over the cable connector 20 either before or after the casting of the insulating composition. For this purpose, the outer portion is so constructed that it may be turned up.

If the end seal illustrated in Figure 1 is to be employed for outdoor installations, the central insulating portion 12 of the mould member 10 is given the form illustrated in the right-hand side of the drawing. In this case, the central insulating portion 12 includes drip shields 21 which form an integral unit therewith. The drip shields 21 may alternatively be subsequently mounted on the insulating portion 12 as separate parts. For the outdoor construction of the terminal seal, the cap-form outer portion 13 may also be provided with drip shields.

WHAT WE CLAIM IS:—

1. A cable comprising a conductor surrounded by a layer of insulation and by a coaxial screen disposed about the insulation, the cable being provided with a terminal seal comprising (a) a multi-part mould member having a tapering metallic inner portion, a central portion formed of an elastomeric insulating material, and a cap-form outer

portion, the terms inner, central and outer being as hereinbefore defined, and (b), as an insulating composition, a mixture of an elastomeric filling compound and an adhesive, the insulating composition being cast within the multi-part mould member and around the cable insulation, and the adhesive ensuring good adhesion between the insulating composition and the cable insulation.

2. A cable as claimed in Claim 1, wherein the insulation surrounding the conductor is formed of a thermoplastic plastics material.

3. A cable as claimed in Claim 2, wherein the insulation surrounding the conductor is formed of a polyvinyl chloride or of a polyethylene.

4. A cable as claimed in Claim 2, wherein the insulation surrounding the conductor is formed of a terpolymeric rubber formed by terpolymerizing ethylene, propylene and a diene monomer.

5. A cable as claimed in any preceding claim, wherein the central portion is cylindrical or outwardly frusto-conically tapering.

6. A cable as claimed in any preceding claim, wherein the central portion is formed of a terpolymeric rubber formed by terpolymerizing ethylene, propylene and a diene monomer.

7. A cable as claimed in any preceding claim, wherein the inner portion is longitudinally divided.

8. A cable as claimed in any preceding claim, wherein the outer portion is formed from an elastomeric material.

9. A cable as claimed in Claim 8, wherein the elastomeric material of the outer portion is weakly conductive.

10. A cable as claimed in any preceding claim, wherein the outer portion is provided with expansion bellows.

11. A cable as claimed in any preceding claim, wherein the coaxial screen is formed of copper.

12. A cable as claimed in any preceding claim, wherein the metallic inner portion is conductively connected to the coaxial screen.

13. A cable as claimed in any preceding claim, wherein the elastomeric filling compound is a mixture of castor oil and polyisocyanic acid esters, converted into an elastomeric condition by cross-linking.

14. A cable as claimed in any preceding claim, wherein the insulation surrounding the conductor and the inner portion are connected by a hose clip.

15. A cable as claimed in any preceding claim, wherein the inner portion and the central portion are connected by means of a hose clip.

16. A cable as claimed in any one of Claims 1 to 14, wherein one of the inner portion and central portion is provided with a groove and the other of the inner portion

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and the central portion is provided with a beading accommodated in said groove.

- 5 17. A cable as claimed in any preceding claim, wherein one of the central portion and the outer portion is provided with a groove and the other of the central portion and the outer portion is provided with a beading accommodated within said groove.

- 10 18. A cable as claimed in Claims 16 or 17, wherein the groove and beading are adhesively bonded together at their connecting faces.

- 15 19. A cable as claimed in Claim 18, wherein the adhesive employed in the region of the connecting faces is the same as the insulating composition.

20. A cable as claimed in any preceding claim, wherein the central portion is provided with drip shields.

- 20 21. A cable as claimed in Claim 19, wherein the drip shields are integral with the central portion.

- 25 22. A cable as claimed in any preceding claim, wherein the outer portion is provided with drip shields.

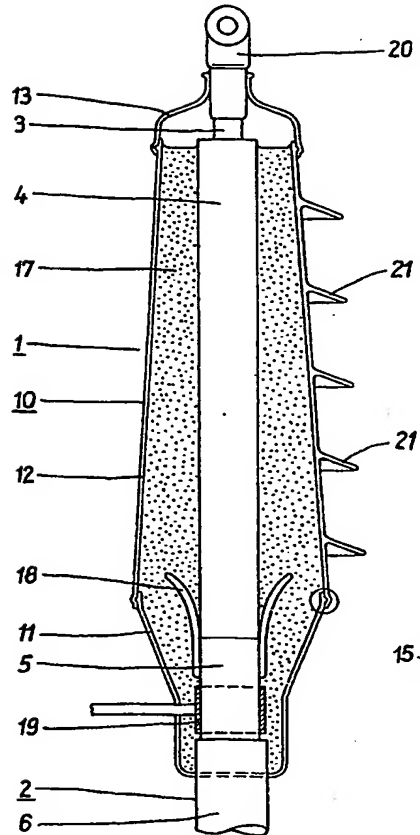
23. A cable having a terminal seal as claimed in Claim 1, substantially as hereinbefore described with reference to, and as illustrated in, the accompanying drawing.

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Fig. 1**Fig. 2**